Multimedia Systems
Lecture – 17

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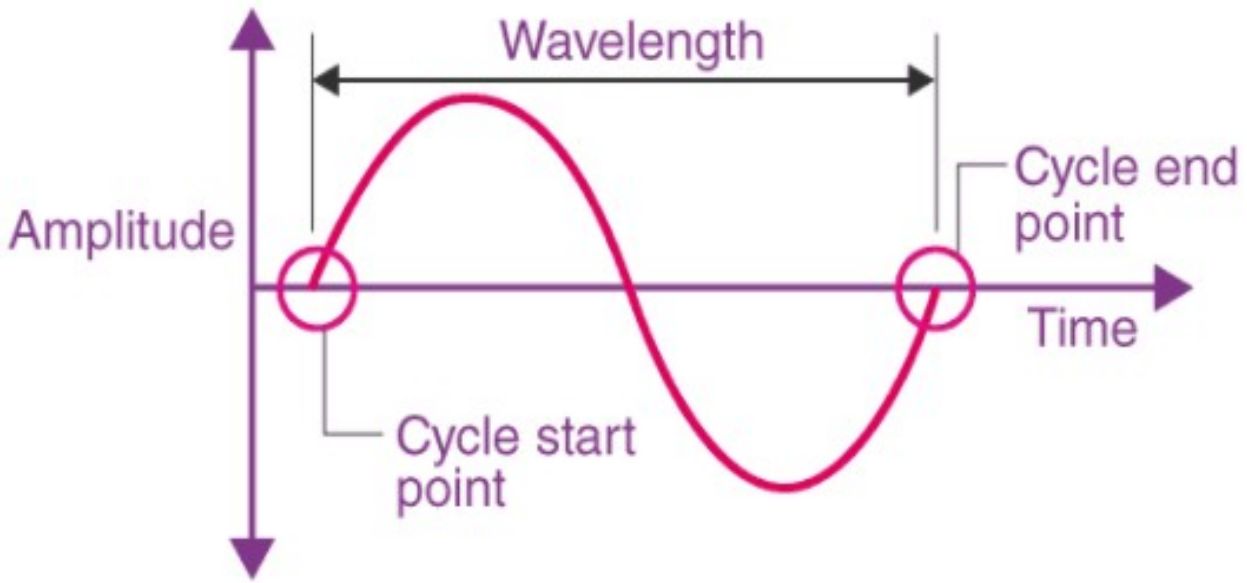
Characteristics of Sound

- The sound wave is having the following characteristics
- Amplitude:
  - It refers to the distance of the maximum vertical displacement of the wave from its mean position.
  - In sound, amplitude refers to the magnitude of compression and expansion experienced by the medium the sound wave is travelling through.
  - This amplitude is perceived by our ears as loudness. High amplitude is equivalent to loud sounds.
- Wavelength:
  - A sound wave is made of areas of high pressure alternated by an area of low pressure.
  - The high-pressure areas are represented as the peaks of the graph. The low-pressure areas are represented as troughs of the graph.
  - The physical distance between two consecutive peaks in a sound wave is referred to as the wavelength of the sound wave.

- Frequency/ Pitch of the Sound Waves
  - Frequency in a sound wave refers to the rate of the vibration of the sound travelling through the air. This parameter decides whether a sound is perceived as high pitched or low pitched.
  - In sound, the frequency is also known as **Pitch**.
  - The frequency of the vibrating source of sound is calculated in cycles per second (Hertz).

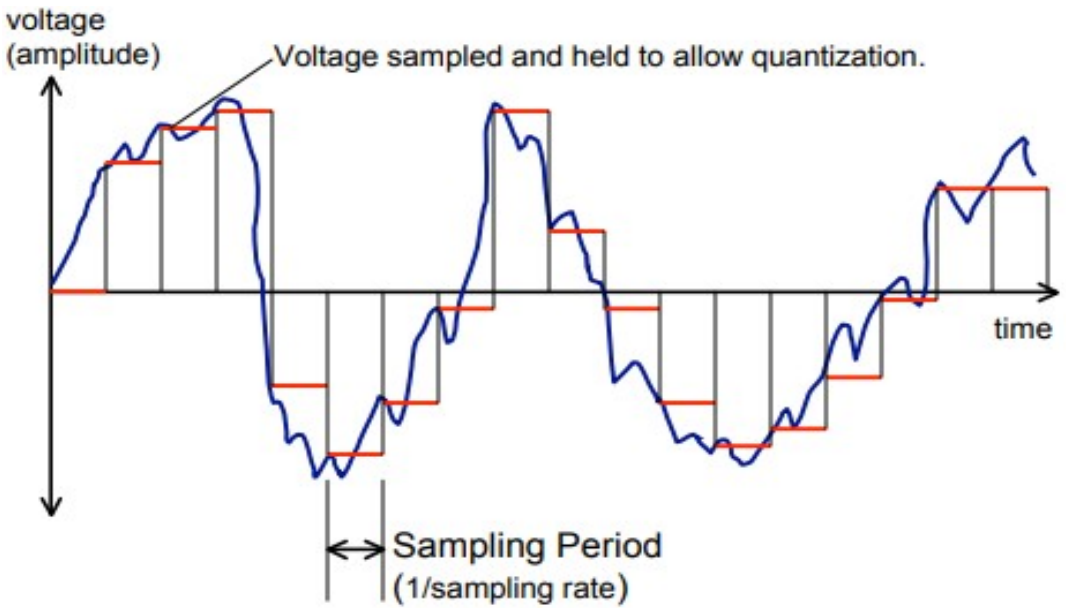
A depiction of Sound Waves in Waveform

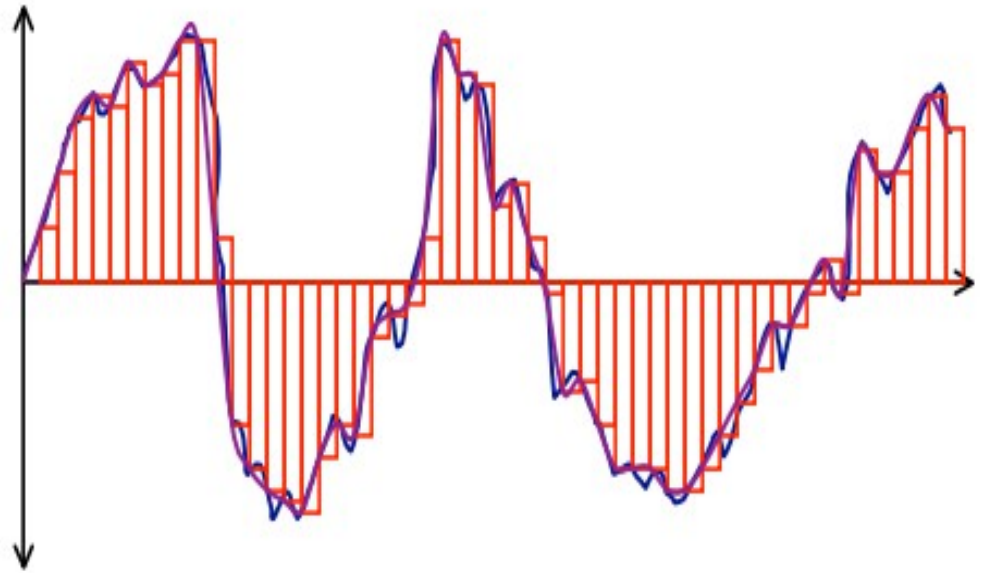


Digitization

- Since there is only one independent variable in sound i.e. time, we call this a 1D signal—as opposed to images, with data that depends on two variables, *x*, and *y*.
- The amplitude value is a continuous quantity. To fully digitize the sound signal, we have to *sample* in time and in amplitude.
- Sampling means measuring the quantity we are interested in, usually at evenly spaced intervals.
- The first kind of sampling—using measurements only at evenly spaced *time* intervals—is simply called *sampling* and the rate at which it is performed is called the *sampling rate* or *sampling frequency*.

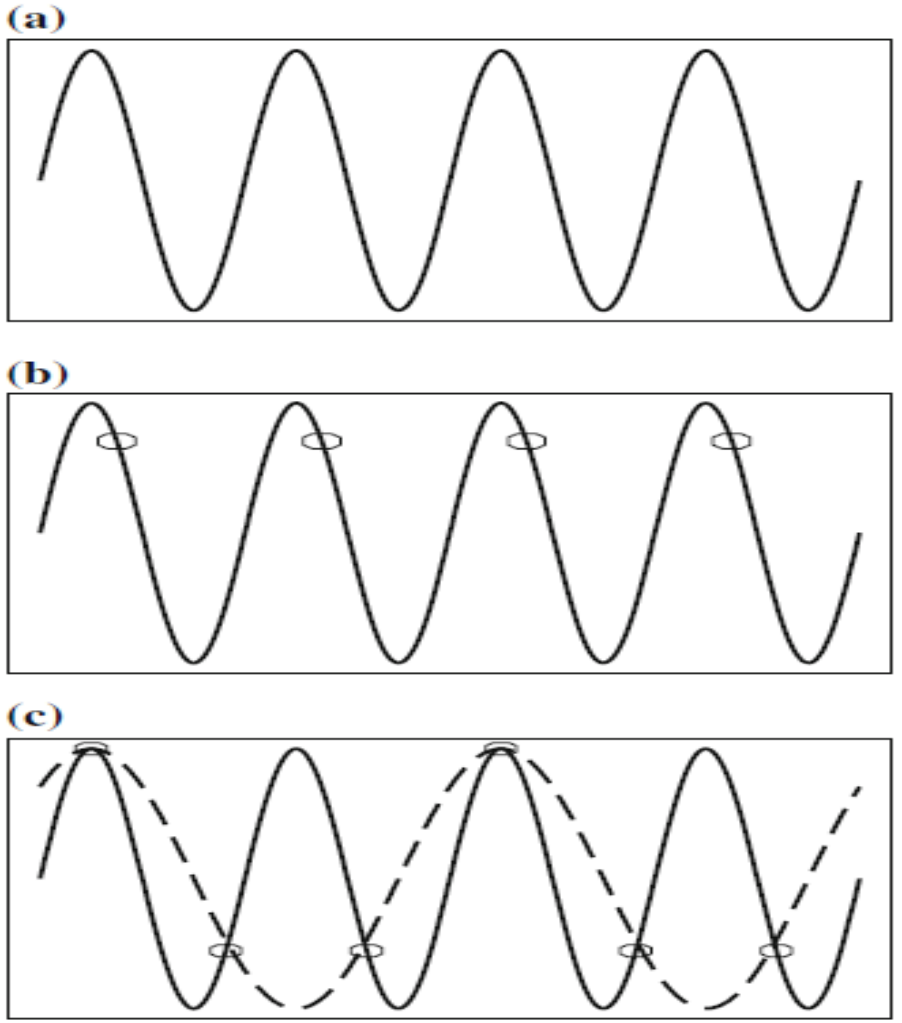
Sampling


voltage
(amplitude)
Voltage sampled and held to allow quantization.
time
Sampling Period
(1/sampling rate)



- For audio, typical sampling rates are from 8 kHz (8,000 samples per second) to 48 kHz.
- The human ear can hear from about *20 Hz to as much as 20 kHz*; above this level, we enter the range of ultrasound.
- The human voice can reach approximately 4 kHz.
- *Nyquist sampling rate :*
  - To preserve the full information in the signal, it is necessary to sample at twice the maximum frequency of the signal. This is known as the Nyquist rate.
  - If we sample the signal at a frequency that is lower that the Nyquist rate, when the signal is converted back into a continuous time signal, it will exhibit a phenomenon called ***aliasing***. Aliasing is the presence of unwanted components in the reconstructed signal.

Aliasing: **a)** a single frequency; **b)** sampling at exactly the frequency produces a constant; **c)** sampling at 1.5 times per cycle produces an *alias* frequency that is perceived



Quantization:

- Sampling in the amplitude or voltage dimension is called *quantization or It* refers to the process of transforming a sampled analog signal, to a digital signal, which has a discrete set of values.
- While we have discussed only uniform sampling, with equally spaced sampling intervals, non-uniform sampling is possible. This is not used for sampling in time but is used for quantization.
- Typical uniform quantization rates are 8-bit and 16-bit; 8-bit quantization divides the vertical axis into 256 levels, and 16-bit divides it into 65,536 levels.
- Quantization Error: A digitized sample can have a maximum error of one-half the discretization step size.

2-bit and 3-bit Quantization